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A research program was conducted to study the effects of steady and unsteady shock impingement on the film-cooing heat transfer turbine blades. The objective of the program is to improve the fundamental physical understanding of how these unsteady phenomena affect the film-cooling heat transfer under simulated thermal and flow conditions typical of real turbine engines. The experimental program is being conducted in the Virginia Tech heated, transonic turbine cascade tunnel. Both steady and unsteady shocks were investigated: the steady shock originates from the trailing edge of the blade and impinges on the suction surface of the adjacent blade; whereas the unsteady shock(s) are generated from a shock tube and pass into the cascade upstream of the blades to simulate the interaction of a moving shock from the upstream stationary nozzle guide vane on the downstream rotating blade row. The blade geometry and film-cooling hole pattern were designed by GE Aircraft Engines.

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# Final Technical Report

Grant # F49620-97-1-0113-DURIP

# A High Speed Motion Analyzer for Research on the Effects of Shock on the Aerodynamic Forcing of Transonic Turbine Blades

Submitted to
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The following is a description of the equipment purchased under this grant:

| Description | Vendor | Amount |
|---|---|---|
| IMACON 468 w/4 CCDs | Hadland Photonics Ltd | $75,000 |
| High Speed Digital Camera | Hadland Photonics Ltd | 75,000 |
| | | 150,000 |
| Less Cost Sharing | | (50,000) |
| Cost to AFOSR | | $100,000 |

Figure 1 is a photograph of the high speed motion analyzer and Figure 2 shows the pictures taken using the motion analyzer in the film-cooling cascade experiment.

**Summary of the Research Project for Which the Equipment was Used**

A research program was conducted to study the effects of steady and unsteady shock impingement on the film-cooing heat transfer turbine blades. The objective of the program is to improve the fundamental physical understanding of how these unsteady phenomena affect the film-cooling heat transfer under simulated thermal and flow conditions typical of real turbine engines. The experimental program is being conducted in the Virginia Tech heated, transonic turbine cascade tunnel. Both steady and unsteady shocks were investigated: the steady shock originates from the trailing edge of the blade and impinges on the suction surface of the adjacent blade; whereas the unsteady shock(s) are generated from a shock tube and pass into the cascade upstream of the blades to simulate the interaction of a moving shock from the upstream stationary nozzle guide vane on the downstream rotating blade row. The blade geometry and film-cooling hole pattern were designed by GE Aircraft Engines.

# DURIP '97
# High Speed Motion Analyzer

Hadland Photonics Ltd: Imacon 468


Featured Capability

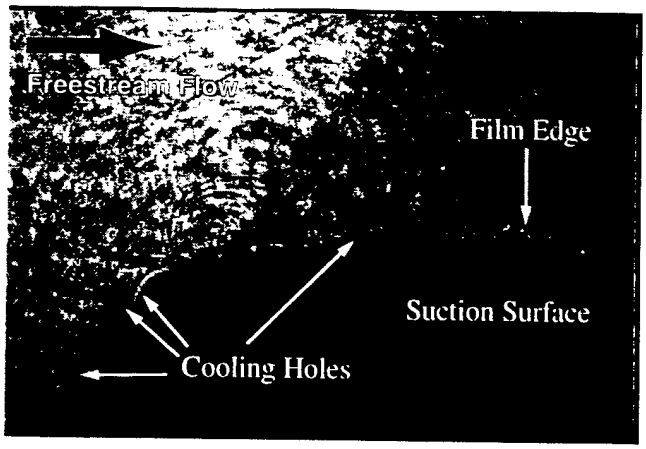
Magnification:
4:5 768x385 CCD with intensifiers (7000 max)

Resolution: 22 line pairs per millimeter

Frame speed: between 10ns and 1ms

Virginia Tech

Figure 1: High Speed Motion Analyzer



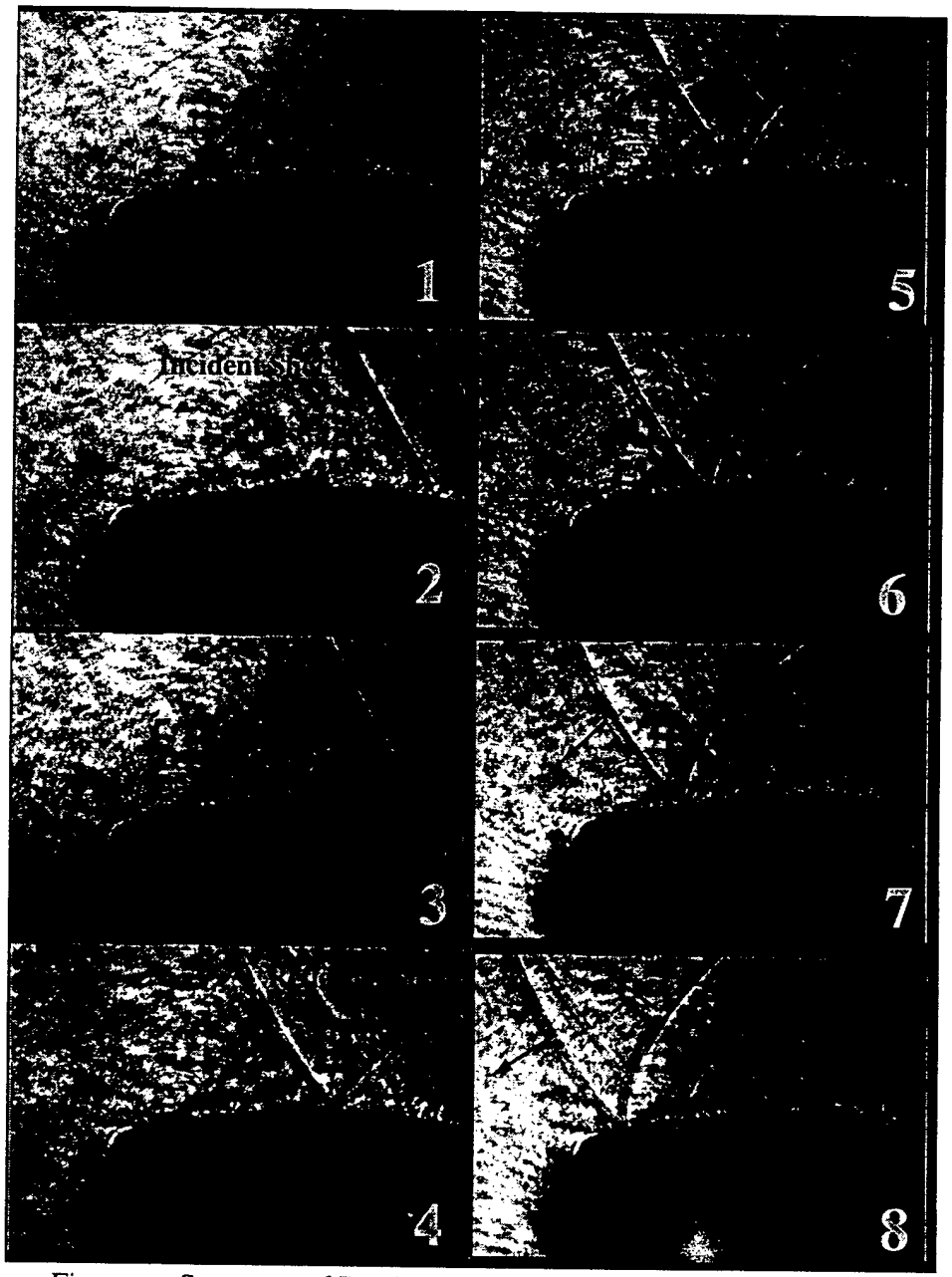




Figure 2: Sequence of Passing Shock Interacting with Cooling Film